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COSTS OF PRODUCING MINE PROPS

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In the heavily industrialized area of north-central Alabama, the forest resource has been depleted to a degree equalled in few other parts of the South. In addition to the usual timber consumption, the best trees of small sizes are continually cut to make props for the region's coal and iron mines. These mines used one-fifth of the wood marketed in the territory in 1945, one-half of it in the form of props.

Today the forests of the region are saddled with large proportions of hardwood stumpage of undesirable species or form, or limby and with considerable butt rot or other defects. Much of this stumpage, though undesirable for other wood products, is still suitable for mine wood, especially props. Such use would reduce the pressure on the more valuable trees--the pines and the hardwoods of good form and species. Although the mines will readily accept hardwood props, cutters are reluctant to produce them as long as pine is available.

Recently the Birmingham Branch of the Southern Forest Experiment Station carried out a study to determine the cost of producing props from low-grade hardwoods and from pine, and to compare the various tools available for logging jobs. This paper presents the results of the study.

Highlights of the Findings

1. For props from the general run of tree sizes, the average direct costs of producing hardwood props were 20 percent greater than the costs of cutting pine props.

2. For felling trees 8 inches d.b.h. and larger, the three-man power chain saw crew is cheaper than the two-man bow saw crew or the two-man crosscut saw crew. This is true, though, only as long as the chain saw is operating steadily; delays quickly reduce its advantage.

3. For bucking logs or bolts larger than 7 inches in diameter, the three-man power chain saw with bow attachment is cheaper (as long as it runs steadily) than any of the tools studied.

4. Splitting the lower bolts from large trees reduces the cost of props.

5. Topping time increases rapidly as diameters larger than 6.5 inches are chopped.

6. Virginia pine is appreciably more expensive to limb than either loblolly or shortleaf pine or hardwoods.

Description of Study

Data were collected in Jefferson County, Alabama, on commercial prop operations and also on the Flat Top Experimental Forest, where props were being produced by the Experiment Station's woods crew. The terrain was moderately rough with few rock outcrops. Ridge tops were generally broad with moderate slopes into drainages. Slopes of 50 to 100 percent were occasionally found.

Although generally quite extensive, the woods road system was poor, most roads being little more than brushed-out rights of way on the ridge tops and gentle slopes. The main county roads were well-graded clay and rock or were paved.

By far the greater portion of the area where the study was made was of the mixed pine-hardwood type--the pines represented primarily by loblolly and shortleaf with some Virginia pine, and the hardwoods mainly by hickory, southern red oak, scarlet oak, black oak, post oak, and white oak. Most of the stands were poorly stocked; they averaged about 100 sound stems per acre (5 inches or larger in d.b.h.), with a volume of about 515 cubic feet per acre ($7\frac{1}{2}$ cords). About one-half of the volume was in trees from 5 to 9 inches in d.b.h., and only 10 percent in trees 15 inches and over.

The heaviest cut removed 85 trees per acre. On the Flat Top Experimental Forest, trees were marked prior to cutting and only about 45 trees per acre were removed.

Nearly all of the mines in the territory are supplied with props by contractors who cut, usually without restriction, on company lands. Most of the contractors observed in the study had had at least five years of experience in cutting props. The Experiment Station woods crew had had about two years' experience in producing props.

Field data were collected during the fall and winter of 1946-47 and during the winter of 1949-50. Temperatures on working days averaged about 60 degrees Fahrenheit. Data for the power saw are based on felling and bucking 829 trees, for the crosscut on 404 trees, and for the bow saw on 396 trees. The range in d.b.h. was from 5 inches through 19 inches, with most trees falling between 5 and 11 inches d.b.h. Skidding data are based on 177 trees and hauling data on 18 loads.

Logging, general.--Prop producers in the territory generally use one of three logging methods, the choice being determined primarily by the terrain and skidding facilities available. Where it is feasible to drive a truck near the felled trees, felling is immediately followed by bucking; the props are then loaded directly onto the truck. Since no skidding is necessary, this procedure is the cheapest but can be employed only on ridge tops and flats. When timber in the hollows or on the lower slopes is to be logged, some skidding is necessary. One method is to fell and buck on the spot, and load the props onto a sled carrying about 20 props. This sled is then pulled by a team to a point accessible to trucks and the props transferred. The third method is to fell and skid tree lengths to a landing at which point the trees are bucked and the props loaded onto the truck. This last procedure is the one applicable to the greatest area and the one to be considered in detail.

Since the present market for props is limited, a producer who wishes to give full time to prop production must usually have one small crew perform all phases of the work. If he has an integrated logging operation, with separate crews for each job, he is likely to find himself overproduced at rather frequent intervals. The contractor or subcontractor usually works as a member of the crew, and for this reason no charge for supervision has been made. This study was concerned with the small single-crew type of operation only.

Method of handling costs.--Two kinds of cost have been recognized, direct and indirect. As used here, direct costs include expenses incurred only when a specific tree is logged; labor is the chief item. Indirect costs are those not affected by the handling of any particular tree, but chargeable to the entire logging job--such as interest and taxes. Some items of expense may include both kinds,

and a proportionate division is not readily determined. Depreciation is partly a matter of time and partly wear through use. For small tools, wear is the more important component; consequently, the entire cost has been treated as a direct cost. For heavy equipment, such as a tractor, the decrease in value is largely a function of time and, therefore, has been treated as an indirect cost.

Felling

Crew organization

Three-man power chain saw, Mall, 24-inch bar.--In felling trees from 5 to 11 inches d.b.h., one man with an 8-foot push pole located marked trees, decided upon direction of fall, and aided in starting fall in the desired direction as the two saw operators cut. Undercuts were made only on the larger trees that were felled against the lean.

Walking time included necessary swamping and delays of less than two minutes' duration; longer delays were separated and listed under delay time. The difference between total elapsed time and the sum of cutting and delay time was divided by the number of trees felled to give average walking time per tree, in this case 43 crew-seconds per tree.

Poor engine performance of the power saw was responsible for delays that amounted to 16 percent of the total elapsed time. Since this test was made, better operation has been obtained by providing a spare spark plug, which allows frequent alternation, and better carburetor adjustment. In view of this and the results of Wiesehuegel[1/] in Tennessee, an estimate of 10 percent for major delays seems reasonable.

The cost of power saw operation, $0.58 per hour, is based on 1,114 hours of use and is classed as a direct cost (see Appendix for details). The $0.028 per hour chargeable to interest, taxes, and the like is by definition an indirect cost. However, since here it is very minor, it will not be separated from the direct costs. An expected life of 2,000 operating hours has been used for depreciation. Other investigators[1/] [2/] have used a considerably longer period, but in view of the present condition of the saw and known facts concerning its care and service, the shorter period seems justified.

1/ Wiesehuegel, E. G. Power chain saws and manual crosscut saws in the production of hardwood logs. South. Lumberman 172(2155): 46-50. 1946.

2/ Campbell, R. A. Pine pulpwood production--a study of hand and power methods. Southeast. Forest Expt. Sta. Tech. Note 66, 19 pp. 1946.

Three-man crosscut saw (5-foot).--As with the chain saw, one man located marked trees, aided when necessary to relieve pinching, and chopped a small undercut on most trees felled. Since all this required less time than the felling and was done while the other crew members were sawing, no time was required in excess of walking time. The men alternated between the different tasks. Walking time per tree was 50 crew-seconds. All charges for tools are considered as direct costs.

Two-man crosscut saw (5-foot), and two-man bow saw (Sandvik 36-inch).--When using either of these tools for prop size trees, one of the two men carried an ax and chopped a small undercut; the two then sawed together. When it was necessary to relieve pinching, one man pushed while the other completed the cut. Here undercutting required time in addition to sawing and walking time, as one man was usually idle during this interval. All costs for tools are considered direct.

Performance

As figure 1 and table 1 show, hardwoods required only about 5 percent more felling time per tree than did pine. In most of the tree sizes studied, the 3-man power chain saw crew proved to be faster and cheaper than any of the other felling methods. Trees were felled in about one-third the time required by crosscut or bow saw crews, and costs were appreciably lower for all trees 8 inches d.b.h. and larger. Delays with the power saw are, however, expensive, and the advantage can easily be wiped out by poor engine performance or an inefficient crew. The greater walking time required by the crosscut saw crew was probably an expression of greater fatigue.

The least efficient felling crew for all size trees studied was the three-man crosscut. For trees up to 9 inches d.b.h. there was little difference between the two-man crosscut

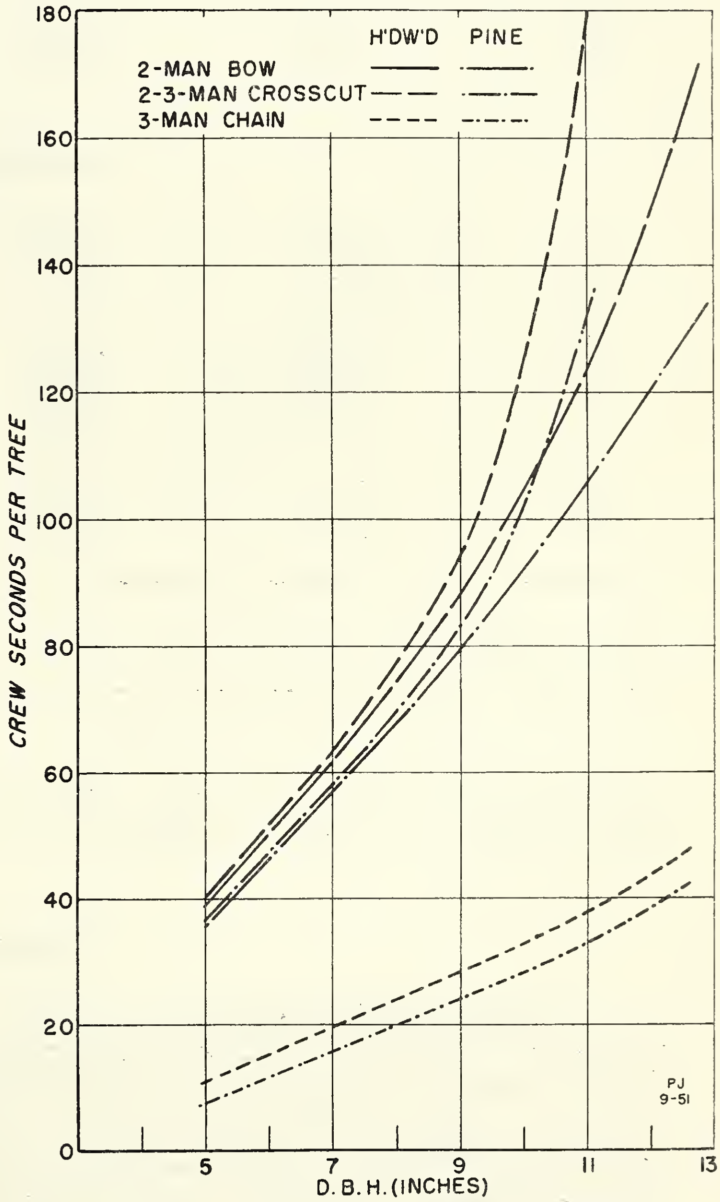

Figure 1.--Time required for felling pine and hardwood trees.

Table 1.--Total direct felling cost per tree[1/]

D.b.h. (inches)	Three-man crosscut saw	Two-man crosscut saw	Two-man bow saw	Three-man chain saw, 24-inch bar
	Dollars			
		PINE		
5	0.059	0.046	0.045	0.047
6	.066	.053	.051	.051
7	.073	.059	.058	.054
8	.081	.066	.065	.058
9	.087	.073	.074	.062
10	.096	.080	.083	.065
11	.104	.088	.093	.070
		HARDWOOD		
5	.061	.048	.046	.051
6	.069	.055	.053	.054
7	.077	.061	.061	.058
8	.086	.069	.069	.062
9	.095	.077	.079	.066
10	.106	.087	.089	.070
11	.120	.098	.111	.075

1/ See Appendix for detailed rates.

and the two-man bow saw crews. But for trees above 9 inches, the two-man crosscut saw crew was superior to the bow saw crew.

Trimming

When skidding was done by tree lengths, the double-bitted ax was used for topping as well as for limbing and for cutting the bole clear of the stump. Topping time varied directly with diameter of cut up to about 6.5 inches inside bark; for sizes larger than this, topping time increased rapidly. However, since most prop trees are topped at points smaller than 6.5 inches, the ax method appears satisfactory. Cutting trees that were not completely severed from the stumps in felling required only a very small portion of the total trimming time.

Time required for limbing the bole varied directly with d.b.h. Virginia pine required appreciably longer to limb than did loblolly or shortleaf pine or the hardwoods. Trimming of hardwoods, although confined to a few large limbs, required on the average about one-third longer than loblolly and shortleaf pine. Figure 2 compares total chopping time required for the different species. Table 2 gives costs for total trimming time. Average walking time per tree was 0.02 man-hour. Here all charges for replacing and maintaining tools are classed as direct costs.

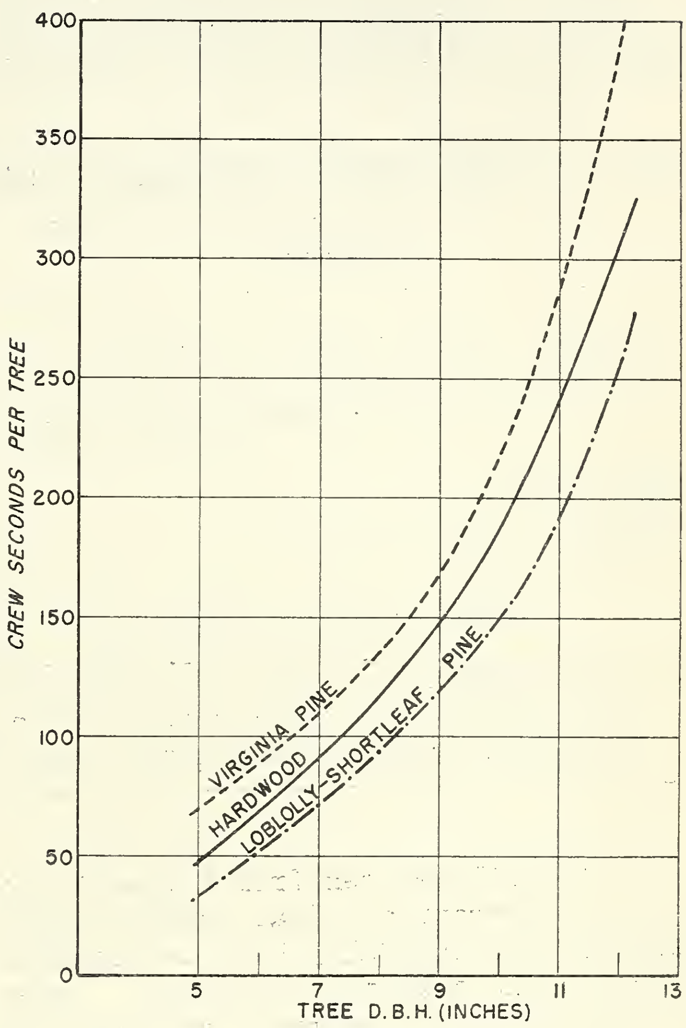

Figure 2.--Total chopping time for trimming pine and hardwood trees.

Table 2.--Total direct trimming cost per tree[1]

D.b.h. (inches)	Loblolly and shortleaf pine	Hardwood	Virginia pine
	- - - Dollars - - -		
5	0.023	0.026	0.032
6	.027	.031	.036
7	.031	.036	.040
8	.036	.042	.046
9	.042	.049	.054
10	.049	.058	.064
11	.059	.069	.079
12	.073	.084	.102

1/ See Appendix for detailed rates.

Skidding

An Oliver "Cletrac" Model BD, 38 horsepower, crawler-type tractor with winch was used for bunching and ground skidding. Two men assisted the operator in dragging cable to trees, in choking, and in unhooking chains at landing. Trees were bunched within an average radius of 35 feet and skidded an average distance of 100 feet. It was not practicable to determine average load by d.b.h. class. However, the study average was three trees per load with most trees in the 9-inch d.b.h. class. Nearly all trees were bunched uphill.

Although skidding time undoubtedly varies with slope, insufficient data were collected to determine the variation by load sizes for different slope percents. Ground skidding was confined to slopes of 15 percent or less; when slopes exceeded 15 percent, trees were bunched by cable. Considerable bunching was done on slopes up to 30 percent. Total direct skidding costs per turn are listed in table 3.

Table 3.--Total direct skidding cost per turn[1]

Operation	Minutes	Dollars
Bunching, three trees in average load	5.00	0.3300
Ground skid and return, per 100 feet	2.75	.1837
Unhooking	.75	.0501
Delay	.50	.0330
Total cost per turn	9.00	0.5968

1/ See Appendix for detailed rates. A turn is the complete trip of the tractor from the landing to the woods, bunching the load of logs, and ground-skidding the load back to the landing.

It will be seen from tables 8 and 9 that skidding is the most expensive operation. Road construction and hauling costs should, therefore, be carefully balanced against costs of skidding in order to determine the cheapest procedure. Taxes and charges for depreciation and interest on investment are termed indirect costs; all others are direct.

Bucking

Crew organization

Three-man power chain saw with bow attachment.--During bucking of trees that were concentrated at a landing, one man marked off the lengths and assisted the two saw operators by placing trees in position for bucking and by moving them when the saw pinched. Cutting required about one-third of the total time and walking and placing trees in position for bucking about one-half. Delays accounted for the remainder.

When piles of trees were large, considerable time was required to move trees and props so that remaining trees could be bucked; often the saw operators had to stop cutting and aid the third man. These large

piles generally contained about 14 trees, but at times as many as 25 trees were skidded to a single landing before bucking. When piles were small, placing trees in position and releasing the saw from pinching could usually be handled by one man without slowing the saw operators unduly. Small piles usually contained about seven trees and were the result of skidding one or two tractor loads to the roadside. Placing the trees in position and walking between cuts required about twice as much time when bucking large piles as when bucking small ones. Details will be found in table 4. These figures indicate that by limiting piles to 6 or 8 trees and leaving about ten feet between piles, bucking costs may be lowered considerably without increasing skidding costs.

Table 4.--Time required for walking between cutting and for placing trees in position for bucking as affected by size of pile[1] at landing and size of trees

D.b.h. of trees in pile (inches)	Two-man bow saw		Three-man chain saw	
	Small piles	Large piles	Small piles	Large piles
	- - - - - Crew seconds per prop - - - - -			
5 to 9	16	33	11	22
5 to 14	27	35	15	21
10 to 14	30	47	10	23

1/ The average number of trees in small piles was 7; in large piles, 14.

Two-man bow saw or two-man crosscut saw.--With either of these tools one man placed the tree in position for bucking and then assisted the other in completing the cut. At times both men were needed to place trees in position. With these tools, cutting accounted for about half of the total time; walking and placing trees in position required a slightly smaller proportion, and delay time was very small. When small piles were bucked, walking between cuts, placing trees in position, and relieving pinching took only one-half to two-thirds as long as for large piles.

Performance

As in felling, the bucking times and costs were only about 5 percent greater for hardwood than for pine. For all diameters, the power saw with bow attachment proved to be faster; it was also cheaper

for diameters larger than 6 inches (figure 3 and table 5). The two-man bow saw competed closely in dollar cost for the small diameters, but cost increased rapidly for diameters 8 inches and over. From about 10 inches and up, the two-man crosscut saw is cheaper than the bow saw. As in felling, poor operation of the power saw was responsible for considerable costly delay. Proper adjustment should limit this delay factor to about 10 percent of total time.

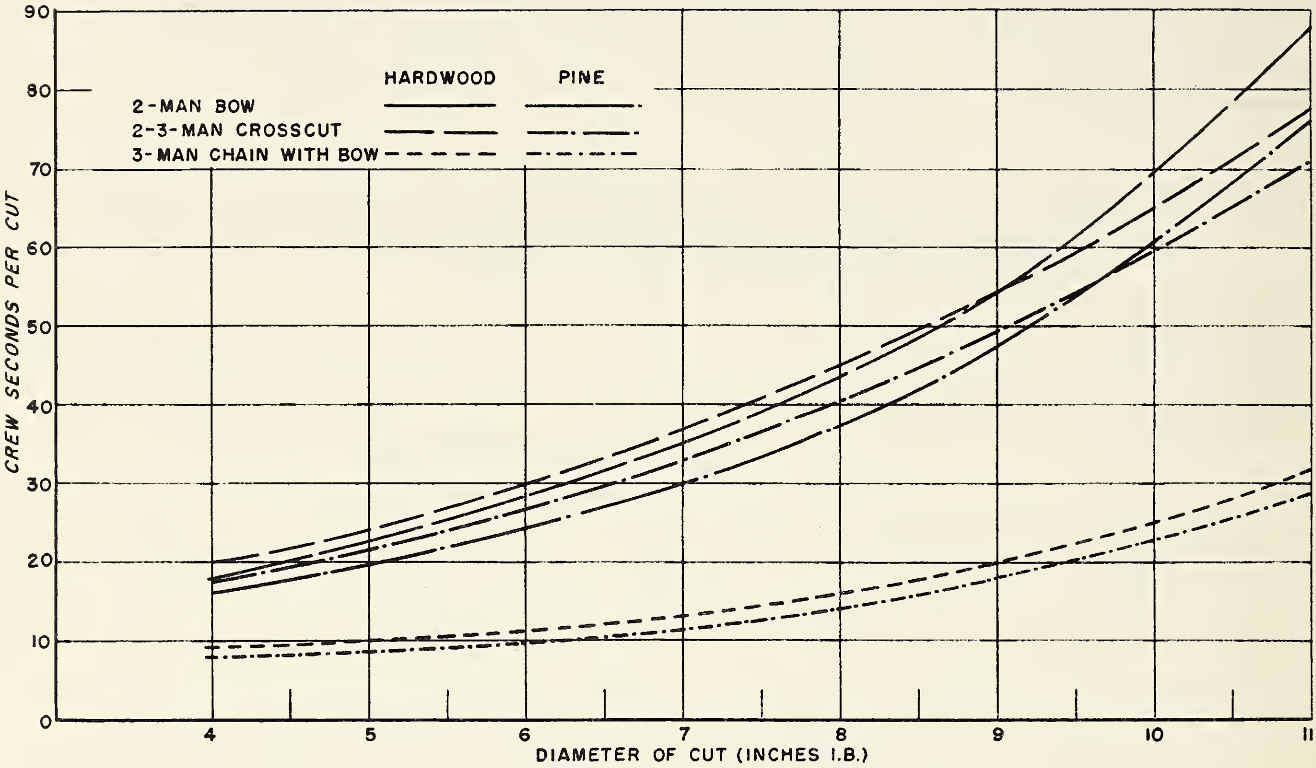

Figure 3.--Cutting time for bucking pine and hardwood.

Data for the one-man bow saw were inadequate for any definite conclusions, but this tool appears to have good possibilities for a man able and willing to stand the strain.

Splitting Large Bolts

Some mines will accept split props that meet minimum specifications. When 3- and 4-foot props are being produced, the lower cuts of trees 8 inches d.b.h. and larger are usually split; for 5- and 6-foot props, trees must usually be 10 inches in d.b.h. before they can be split. In large timber, several props can sometimes be split from one bolt, but in this study the trees were so small that no more than two props could be split from any one section.

Table 5.--Total direct bucking cost per cut 1/

Diameter of cut inside bark (inches)	Two-man crosscut saw	Two-man bow saw	Three-man chain saw with bow attachment
	Dollars		
		PINE	
4	0.019	0.017	0.019
5	.021	.018	.019
6	.023	.020	.020
7	.026	.024	.022
8	.030	.027	.024
9	.034	.032	.028
10	.039	.038	.030
11	.044	.045	.033
		HARDWOOD	
4	.020	.019	.020
5	.022	.020	.020
6	.024	.023	.021
7	.028	.026	.023
8	.032	.030	.026
9	.036	.035	.029
10	.041	.042	.035
11	.047	.050	.041

1/ See Appendix for detailed rates.

Splitting costs were found to vary with length of props being produced. On the average, splitting required 1.1 manhours per 100 3- or 4-foot props and 1.8 manhours for 100 5- or 6-foot props. As tables 8 and 9 show, splitting reduced production costs considerably, both for hardwood and for pine props. If anything, the savings were greater in hardwood.

Loading and Hauling

Three men usually did the loading from small piles scattered along a woods road or from large piles, either "as bucked" or neatly stacked. Since stacking required about one man-hour per load of approximately two cords, and since there was no practical difference between loading times by the three procedures, loading from large stacked piles is the least efficient.

Two men could readily load and unload props six feet in length or shorter. It was not practicable to determine loading time for sizes of props cut from each d.b.h. class. Likewise, the number of props per load given in table 6 are averages for props cut from trees of different sizes; the number per load would undoubtedly vary with diameter of trees from which they were cut. Loading and unloading accounted for over 60 percent of the total time, hauling to the mine and return for about 20 percent, and delays for about 20 percent. Most of the delay time accumulated at the mine while the men waited for the load to be checked.

Table 6.--Size requirements, number in load, and unit price of mine props

Prop size		Average in load		Average delivered price
Length (feet)	Min. diameter (inches)	Pine	Hardwood	
		- Number -		Dollars per prop
3	4	362	338	0.08
4	4	242	225	.11
5	5	175	170	.18
6	5	160	154	.21

Delivering props from the cutting area to the mine involved an average haul of $\frac{1}{2}$ mile on woods roads and 2 miles on improved gravel or asphalt road. Sufficient data will be found in table 7 and in the Appendix to determine costs for the longer hauls required of most contractors. The average load per truck was two cords. Charges for depreciation, license fees, taxes, insurance, and interest on the truck are indirect costs; all other are direct.

Table 7.--Total direct loading and hauling costs

Prop size: Length (feet)	Prop size: Av. diam. small end, i.b. (inches)	Loading (three men)	Unloading (two men)	Delay (two men)	Hauling (two men)	Total time for 3-man crew	Cost: Tools and truck	Cost: Labor	Cost: Total
		- - Man-hours per load - -					Dollars per load		
3	4.2	2.00	1.00	0.67	0.67	4.34	0.67	3.52	4.19
6	5.5	1.50	.50	.67	.67	3.34	.67	2.71	3.38
6	8.3	2.00	.67	.67	.67	4.01	.67	3.25	3.92
7	5.5	1.50	.50	.67	.67	3.34	.67	2.71	3.38

Production Costs Per 100 Props

So far, costs have been given only in terms of specific operations, without regard to the total cost of producing a given quantity of props from trees of different size classes. To complete the comparison, however, it is necessary to compute the cost of producing a given quantity of props from trees of each d.b.h. class in both hardwood and pine. This has been done in tables 8 and 9, which give costs for units of 100 props.

The tables show that the direct costs per 100 props range from 10 to 40 percent greater for hardwood than for pine. The chief cause of this important differential is that the upland oaks and hickories in this territory have shorter boles than the pines (or yellow-poplar, which was not included in this study), a fact that necessitates handling more hardwood trees than pines in order to get a given quantity of props (see column 3 of tables 8 and 9). On the average, for props from the general run of tree sizes, the hardwood props will cost about 20 percent more to produce than pine props.

In computing tables 8 and 9, the most efficient tools of those covered in the study were selected. In table 8 the costs for felling and bucking are those for the two-man bow saw crew, which is the most efficient crew for sawing trees 8 inches in d.b.h. and smaller. Five- and six-foot props are usually cut from trees 8 inches in d.b.h. and larger, and for this reason the costs of producing them with a bow saw have not been included. In table 9 the costs for felling are those for the power chain saw with a 24-inch bar and a 3-man crew, and for bucking the power chain saw with a bow attachment and a 3-man crew. The power chain saw is the most efficient tool in all respects for sawing trees over 9 inches in d.b.h.

Table 8A.--Pine props: direct costs of production per 100 props, using two-man bow saw crew for felling and bucking

Tree d.b.h. (inches) (1)	Av. utilized volume per tree to minimum top diam., outside bark, of 4 in. (2)	Trees per 100 props (3)	Labor costs: Felling (4)	Labor costs: Trimming (5)	Labor costs: Skidding (6)	Labor costs: Bucking[1] (7)	Labor costs: Hauling[2] (8)	Labor costs: Total stump to mine (9)	Costs other than labor: Felling bucking & trimming (10)	Costs other than labor: Skidding (11)	Costs other than labor: Hauling[2] (12)	Costs other than labor: Total stump to mine (13)
	Cords	Number	Man-hours						Dollars[3]			
			THREE-FOOT PROPS									
5	0.018	23.1	1.34	0.67	2.60	1.81	1.20	7.75	0.10	1.01	0.19	1.30
6	.030	14.6	.95	.50	1.75	1.86	1.20	6.37	.09	.68	.19	.96
7	.051	11.5	.86	.46	1.51	1.94	1.20	6.00	.09	.58	.19	.86
[4] 8	.079	10.0	.84	.46	1.39	2.11	1.20	5.89	.09	.54	.19	.82
[4] 9	.108	9.0	.83	.48	1.35	2.33	1.20	5.94	.10	.52	.19	.81
[5] 8	.079	9.1	.76	.42	1.26	2.02	1.20	5.57	.09	.49	.19	.77
[5] 9	.108	7.6	.70	.40	1.14	2.15	1.20	5.55	.08	.44	.19	.71
			FOUR-FOOT PROPS									
5	.018	30.8	1.78	.89	3.46	1.78	1.79	9.86	.11	1.34	.28	1.73
6	.030	19.5	1.27	.66	2.34	1.86	1.79	8.03	.10	.90	.28	1.28
7	.051	15.4	1.15	.60	2.02	1.94	1.79	7.53	.10	.78	.28	1.16
[4] 8	.079	13.3	1.11	.61	1.85	2.06	1.79	7.36	.10	.72	.28	1.10
[4] 9	.108	11.9	1.09	.63	1.79	2.22	1.79	7.36	.11	.69	.28	1.08
[5] 8	.079	11.8	.99	.54	1.64	1.95	1.79	6.85	.09	.63	.28	1.00
[5] 9	.108	9.6	.88	.51	1.44	2.01	1.79	6.71	.09	.56	.28	.93

Table 8B.--Hardwood props: Direct costs of production per 100 props, using two-man bow saw crew for felling and bucking

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
			THREE-FOOT PROPS									
5	.009	50.0	2.98	1.65	5.62	1.89	1.28	13.53	0.17	2.17	0.20	2.54
6	.024	23.2	1.56	.90	2.78	2.00	1.28	8.52	.12	1.08	.20	1.40
7	.043	16.9	1.31	.76	2.22	2.17	1.28	7.63	.12	.86	.20	1.18
[4] 8	.064	14.1	1.23	.73	1.96	2.33	1.28	6.99	.11	.76	.20	1.07
[4] 9	.090	12.3	1.22	.75	1.84	2.69	1.28	7.34	.12	.71	.20	1.03
[5] 8	.064	12.4	1.08	.64	1.72	2.20	1.28	6.43	.04	.67	.20	.91
[5] 9	.090	9.8	.97	.60	1.47	2.38	1.28	6.55	.03	.57	.20	.80
			FOUR-FOOT PROPS									
5	0.009	66.7	3.98	2.20	7.50	1.72	1.93	17.61	.19	2.90	.30	3.39
6	.024	31.2	2.10	1.22	3.74	2.00	1.93	10.99	.14	1.45	.30	1.89
7	.043	22.7	1.76	1.02	2.98	2.19	1.93	9.75	.13	1.15	.30	1.58
[4] 8	.064	18.5	1.61	.96	2.58	2.33	1.93	9.19	.13	1.00	.30	1.43
[4] 9	.090	16.4	1.62	1.00	2.46	2.56	1.93	9.23	.14	.95	.30	1.39
[5] 8	.064	15.6	1.36	.81	2.18	2.14	1.93	8.23	.11	.84	.30	1.25
[5] 9	.090	14.1	1.39	.86	2.12	2.36	1.93	8.56	.12	.82	.30	1.24

1/ Figures in this column were determined in the following manner: From taper tables, the diameters at 3- and 4-foot intervals were determined; from Figure 3 and Table 5 the costs of bucking these diameters were determined and averaged for each d.b.h. class. This average figure was multiplied by 100 to get the cost per 100 props. When split props are included (see footnote 5) the average cost by d.b.h. was determined as before but was multiplied by the number of cuts necessary to produce 100 round and split props combined. To this bucking cost was added the cost of splitting those props that were large enough.

2/ Cost per load was multiplied by the factor $\frac{100}{\text{Number of props per average load}}$; each load contained about two cords.

3/ Expressed in 1950 dollars.

4/ Data in this line are for round props.

5/ Data include split props meeting mine specifications.

Table 9A.--Pine props: Direct costs of production per 100 props, using three-man power chain saw crew for felling and bucking

Tree d.b.h. (inches) (1)	Average utilized volume per tree[1] (2)	Trees per 100 props (3)	Labor costs: Felling (4)	Labor costs: Trimming (5)	Labor costs: Skidding (6)	Labor costs: Bucking[2] (7)	Labor costs: Hauling[3] (8)	Labor costs: Total stump to mine (9)	Costs other than labor: Felling and trimming (10)	Costs other than labor: Skidding (11)	Costs other than labor: Bucking[2] (12)	Costs other than labor: Hauling[3] (13)	Costs other than labor: Total stump to mine (14)
	Cords	Number	Man-hours						Dollars[4]				
						THREE-FOOT PROPS							
5	0.018	23.1	1.09	0.67	2.60	1.94	1.20	7.50	0.22	1.01	0.38	0.19	1.80
6	.030	14.6	.74	.50	1.75	1.97	1.20	6.16	.15	.68	.38	.19	1.40
7	.051	11.5	.63	.46	1.51	1.97	1.20	5.77	.13	.58	.38	.19	1.28
[5]8	.079	10.0	.58	.46	1.39	2.00	1.20	5.63	.12	.54	.39	.19	1.24
[5]9	.108	9.0	.56	.48	1.35	2.08	1.20	5.67	.12	.52	.40	.19	1.23
[6]8	.079	9.1	.54	.42	1.27	1.92	1.20	5.35	.11	.49	.36	.19	1.15
[6]9	.108	7.6	.47	.40	1.14	2.11	1.20	5.32	.10	.44	.35	.19	1.08
						FOUR-FOOT PROPS							
5	0.018	30.8	1.45	.89	3.46	1.94	1.79	9.53	.30	1.34	.38	.28	2.30
6	.030	19.5	.99	.66	2.34	1.97	1.79	7.75	.21	.90	.38	.28	1.77
7	.051	15.4	.84	.60	2.02	1.97	1.79	7.22	.18	.78	.38	.28	1.62
[5]8	.079	13.3	.78	.61	1.85	2.00	1.79	7.03	.16	.72	.39	.28	1.55
[5]9	.108	11.9	.74	.63	1.79	2.06	1.79	7.01	.16	.69	.40	.28	1.53
[6]8	.079	11.8	.69	.54	1.64	1.89	1.79	6.55	.15	.63	.34	.28	1.40
[6]9	.108	9.6	.60	.51	1.44	2.09	1.79	6.43	.13	.56	.32	.28	1.29
						FIVE-FOOT PROPS							
5	.011	55.6	2.62	1.61	6.20	1.94	1.90	14.27	.54	2.43	.38	.38	3.73
6	.024	31.2	1.59	1.06	3.74	1.94	1.90	10.23	.33	1.45	.38	.38	2.54
7	.043	22.7	1.24	.89	2.98	1.97	1.90	8.98	.26	1.15	.38	.38	2.17
8	.069	18.5	1.08	.85	2.58	2.00	1.90	8.41	.23	1.00	.39	.38	2.00
9	.096	16.7	1.04	.89	2.51	2.06	1.90	8.40	.22	.97	.40	.38	1.97
[5]10	.125	15.2	1.00	.93	2.42	2.19	1.90	8.44	.21	.94	.43	.38	1.96
[5]11	.152	14.3	1.01	1.04	2.43	2.33	1.90	8.71	.22	.94	.45	.38	1.99
[6]10	.125	13.2	.87	.81	2.10	2.14	1.90	7.82	.19	.81	.37	.38	1.75
[6]11	.152	12.5	.88	.91	2.13	2.32	1.90	8.14	.19	.82	.40	.38	1.79
						SIX-FOOT PROPS							
5	.011	66.7	3.15	1.93	7.50	1.94	2.08	16.60	.65	2.90	.38	.42	4.35
6	.024	37.0	1.88	1.26	4.44	1.94	2.08	11.60	.39	1.72	.38	.42	2.91
7	.043	27.0	1.48	1.05	3.54	1.97	2.08	10.12	.31	1.37	.38	.42	2.48
8	.069	22.2	1.29	1.02	3.09	2.00	2.08	9.48	.27	1.19	.39	.42	2.27
9	.096	20.0	1.24	1.06	3.00	2.06	2.08	9.44	.26	1.16	.40	.42	2.24
[5]10	.125	18.2	1.20	1.11	2.90	2.17	2.08	9.46	.26	1.12	.42	.42	2.22
[5]11	.152	17.2	1.21	1.26	2.92	2.33	2.08	9.80	.26	1.13	.45	.42	2.26
[6]10	.125	15.4	1.01	.94	2.45	2.12	2.08	8.60	.21	.95	.36	.42	1.94
[6]11	.152	14.7	1.03	1.07	2.50	2.31	2.08	8.99	.22	.97	.39	.42	2.00

1/ To a minimum 4-inch top (inside bark) for 3- and 4-foot props; and to a 5-inch top for 5- and 6-foot props.

2/ Figures in this column were determined in the following manner: From taper tables, the diameters (at 3- and 4-foot intervals for 3- and 4-foot props, and 5- and 6-foot intervals for 5- and 6-foot props) were determined; from Figure 3 and Table 5 the costs of bucking these diameters were determined and averaged for each d.b.h. class. This average figure was multiplied by 100 to get the cost per 100 props. When split props are included (see footnote 6) the average cost by d.b.h. was determined as before but was multiplied by the number of cuts necessary to produce 100 round and split props combined. To this bucking cost was added the cost of splitting those props that were large enough.

3/ Cost per load was multiplied by the factor $\frac{100}{\text{Number of props per average load}}$; each load contained about two cords.

4/ Expressed in 1950 dollars.

5/ Data in this line are for round props.

6/ Data include split props meeting mine specifications.

Table 9B.--Hardwood props: Direct costs of production per 100 props, using three-man power chain saw crew for felling and bucking

Tree d.b.h. (inches)	Average utilized volume per tree1/	Trees per 100 props	Labor costs						Costs other than labor				
			Felling	Trimming	Skidding	Bucking2/	Hauling3/	Total stump to mine	Felling and trimming	Skidding	Bucking2/	Hauling3/	Total stump to mine
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Cords	Number	Man-hours						Dollars4/				
			THREE-FOOT PROPS										
5	0.009	50.0	2.50	1.65	5.62	2.00	1.28	13.05	0.52	2.17	0.39	0.20	3.28
6	.024	23.2	1.26	.90	2.78	2.00	1.28	8.22	.26	1.08	.39	.20	1.93
7	.043	16.9	.99	.76	2.22	2.06	1.28	7.31	.21	.86	.40	.20	1.67
5/8	.064	14.1	.87	.41	1.96	2.11	1.28	6.63	.18	.76	.41	.20	1.55
5/9	.090	12.3	.81	.75	1.84	2.25	1.28	6.93	.17	.71	.44	.20	1.52
6/8	.064	12.4	.77	.36	1.72	1.99	1.28	6.12	.16	.67	.36	.20	1.39
6/9	.090	9.8	.65	.60	1.47	2.23	1.28	6.23	.14	.57	.37	.20	1.28
			FOUR-FOOT PROPS										
5	.009	66.7	3.34	2.20	7.53	2.00	1.93	17.00	.69	2.90	.39	.30	4.28
6	.024	31.2	1.69	1.22	3.74	2.00	1.93	10.58	.35	1.45	.39	.30	2.49
7	.043	22.7	1.32	1.02	2.98	2.06	1.93	9.31	.28	1.15	.40	.30	2.13
5/8	.064	18.5	1.15	.96	2.58	2.11	1.93	8.73	.24	1.00	.41	.30	1.95
5/9	.090	16.4	1.09	1.00	2.46	2.22	1.93	8.70	.23	.95	.43	.30	1.91
6/8	.064	15.6	.97	.81	2.18	1.95	1.93	7.84	.20	.84	.35	.30	1.69
6/9	.090	14.1	.93	.86	2.12	2.26	1.93	8.10	.20	.82	.38	.30	1.70
			FIVE-FOOT PROPS										
6	.018	50.0	2.71	1.65	6.00	2.00	1.96	14.32	.56	2.32	.39	.39	3.66
7	.038	33.3	1.94	1.50	4.37	2.06	1.96	11.83	.41	1.69	.40	.39	2.89
8	.060	26.3	1.63	1.37	3.66	2.08	1.96	10.70	.34	1.42	.40	.39	2.55
9	.083	22.7	1.50	1.38	3.41	2.19	1.96	10.44	.32	1.32	.43	.39	2.46
5/10	.109	20.4	1.43	1.47	3.25	2.31	1.96	10.42	.31	1.26	.45	.39	2.41
5/11	.130	19.2	1.62	1.65	3.26	2.44	1.96	10.93	.35	1.26	.47	.39	2.47
6/10	.109	16.9	1.19	1.22	2.69	2.22	1.96	9.28	.26	1.04	.38	.39	2.07
6/11	.130	16.1	1.36	1.38	2.74	2.41	1.96	9.85	.29	1.06	.41	.39	2.15
			SIX-FOOT PROPS										
6	.018	58.8	3.19	2.29	7.06	2.00	2.16	16.70	.66	2.73	.39	.44	4.22
7	.038	40.0	2.33	1.80	5.25	2.03	2.16	13.57	.49	2.03	.39	.44	3.35
8	.060	31.2	1.93	1.62	4.35	2.08	2.16	12.14	.41	1.68	.40	.44	2.93
9	.083	27.0	1.79	1.65	4.05	2.19	2.16	11.84	.38	1.57	.42	.44	2.81
5/10	.109	24.0	1.69	1.76	3.88	2.25	2.16	11.74	.36	1.50	.44	.44	2.74
5/11	.130	23.3	1.96	2.00	3.96	2.42	2.16	12.50	.42	1.53	.47	.44	2.86
6/10	.109	19.6	1.38	1.41	3.12	2.16	2.16	10.23	.30	1.21	.36	.44	2.31
6/11	.130	18.8	1.58	1.62	3.20	2.40	2.16	10.96	.34	1.24	.39	.44	2.41

1/ To a minimum 4-inch top(inside bark) for 3- and 4-foot props; and to a 5-inch top for 5- and 6-foot props.

2/ Figures in this column were determined in the following manner: From taper tables, the diameters (at 3- and 4-foot intervals for 3- and 4-foot props, and 5- and 6-foot intervals for 5- and 6-foot props) were determined; from Figure 3 and Table 5 the costs of bucking these diameters were determined and averaged for each d.b.h. class. This average figure was multiplied by 100 to get the cost per 100 props. When split props are included (see footnote 4) the average cost by d.b.h. was determined as before but was multiplied by the number of cuts necessary to produce 100 round and split props combined. To this bucking cost was added the cost of splitting those props that were large enough.

3/ Cost per load was multiplied by the factor $\frac{100}{\text{Number of props per average load}}$; each load contained about two cords.

4/ Expressed in 1950 dollars.

5/ Data in this line are for round props.

6/ Data include split props meeting mine specifications.

All trees 7 inches in d.b.h. and larger can be felled most efficiently with the power chain saw, but trees under 9 inches in d.b.h. can be bucked at lower cost with a Swedish-type bow saw. A combination of these two tools would, therefore, provide the most efficient means for felling and bucking in the production of mine props.

Although butt cuts of the larger trees are usually split, the costs of producing the round props are included for comparison and for use of producers of other products.

A power chain saw will usually reduce costs when trees 8 inches d.b.h. and larger are logged. However, farmers or part-time loggers will probably find that the high initial cost cannot be depreciated within a reasonable length of time, while hand tools are low in cost and quite efficient in logging. Such operators, too, would find it advisable to skid with mules. Mules would be restricted by steep slopes and rough terrain, but on average operations can skid about 100 lineal feet of prop-size trees in an hour.

The data in tables 8 and 9 may readily be adapted to other products--such as fence posts, pulpwood, or chemical wood--with similar size requirements. For such purposes the figures may be expressed in cords instead of 100 props. Cords per 100 props can be determined by multiplying the appropriate value in column 2 by its corresponding value in column 3. When divided by the resulting product, costs in the table will be converted to a cord basis. For example, the labor cost for felling when producing 100 five-foot props from eight-inch pine trees is 1.08 man-hours. The volume produced is 0.069 cord per tree (column 2) times 18.5 trees per 100 props (column 3) or 1.28 cords per 100 props. Thus 1.08 man-hours is required to produce 1.28 cords--or 0.85 man-hour per cord.

Indirect costs applicable to the tractor and truck will be found in the Appendix.

Implications of the Study for the Land Manager

In the Birmingham territory, props are sold by the piece, delivered at the mine; the price varies with the size of the prop. Since it costs more to make props from hardwoods than from pine, this procurement policy encourages the contractor to take the best trees and leave the short, low-quality boles. The result is that the prop contractor gets his return partly at the expense of the income that the landowner could realize by managing his forest for high-grade saw timber, either pine or good-quality hardwoods. Since good timber is extremely scarce in the territory, the loss probably is considerable. Much of it falls on the mines themselves, for many of the props that the mines purchase are cut, without restriction as to species or type of tree, from company lands.

Landowners could encourage the cutting of low-quality trees by exacting no stumpage or royalty for them, while demanding fair value for the better hardwoods and the pine. Another course might be to restrict cutting to Virginia pine and hardwoods (except yellow-poplar). Mines could readily control such cutting through the timber checker at the mine. The improvement in its own forests might also justify a mine in paying enough of a premium for hardwood props to offset the contractor's extra expense in producing them. Steps like these would not by themselves rehabilitate the region's forests, but they would be a realistic start and would help to relieve the pressure on trees of high potential value.

Appendix

Table 10.--Direct tool cost rates per crew for power chain saw

Item	Cost per hour
	Dollars
Depreciation (excluding chains)	0.275
Interest, taxes, etc. (10 percent of average annual investment 1/)	.028
Repairs (excluding chains)	.127
Chains (wear, repair, and sharpening)	.089
Gasoline (0.189 gallon per hour)	.047
Oil (0.093 quart per hour)	.019
Total	.585

1/ An indirect cost here classified as direct for convenience since it is very small.

Data from which costs were determined.--Work year: 250 eight-hour days or 2,000 hours. Expected life of saw: 2,000 hours of operation; of chain, 300 hours. Cost (1947) of saw with 24-inch bar and 18-inch bow (excluding chains): $550. Cost of 24-inch chain, $19; 36-inch chain, $27. Sharpening chains: by machine, once in 150 operating hours at $3.00. By hand filing, once in 30 operating hours, ¼-hour. These data cover 1,114 hours of operation, during which 211 gallons of gasoline (at $0.25) and 104 quarts of oil (at $0.20) were consumed. The costs for repairs, parts, and labor were $141.48.

Table 11.--Direct tool cost rates per crew for crosscut saw, bow saw, and ax

Item	Crosscut saw 2/	Bow saw 3/	Double-bitted ax 4/
	- - Dollars per hour - -		
Depreciation (1/2000 of annual equipment cost)	0.013	0.010	0.004
Maintenance, including labor	.048	.049	.023
Interest, taxes, etc. (10 percent of average annual investment) 1/	.001	.001	...
Total	.062	.060	.027

1/ For crosscut and bow saws, an indirect cost classed as direct for convenience inasmuch as it is a very small item. For the ax, indirect costs are negligible.

2/ Crosscut saw. Estimated cost of equipment: two saws at $9.50, two axes at $3.50, or $26.00 per year. Maintenance charges: one file every four weeks at $0.20; one-half hour labor per day at $0.75.

3/ Bow saw. Estimated annual costs of equipment: one saw frame at $4.75; four blades at $1.95; two axes at $3.50, or $19.55 per year. Maintenance charges: one file kit per five years; one file every four weeks at $0.20; 1/2 hour labor per day at $0.75.

4/ Ax. Estimated annual costs of equipment: two axes at $3.50; two handles at $0.75; or $8.50 per year. Maintenance charges: one file every eight weeks at $0.20; ¼ hour labor per day at $0.75.

Table 12.--Equipment costs, Ford $1\frac{1}{2}$-ton stake truck

Item	Indirect costs per year	Direct costs per mile: Woods road	Direct costs per mile: Improved road
	- - - - - -	Dollars	- - - - - -
Depreciation	542		
License	23		
Interest, taxes, insurance, etc. (10 percent of av. annual investment)	122		
Total	687		
Tires		0.118	0.063
Gasoline		.050	.028
Oil and grease (estimated)		.003	.003
Repairs, parts, and labor (estimated)		.025	.025
Total direct cost per mile		.196	.119
Total direct cost per hour		1.058	2.689

Data from which costs were determined.--Vehicle: 95 hp; cost \$1956; estimated life, 4,000 hours; estimated trade-in value, \$400. Tires: 7.50-20, 10 ply; cost \$78.91 each, including tubes and taxes; estimated life: on woods road 4,000 miles; on improved road, 7,500 miles. Mileage: woods road, 5 miles per gallon; improved road, 9 miles per gallon; gasoline at \$0.25. Average speeds: woods road, 5.4 mph; improved road, 22.6 mph.

Table 13.--Equipment costs, Oliver Cletrac 38 horsepower tractor

Item	Indirect costs per year	Direct costs per hour
	- - Dollars - -	
Depreciation	1,667	
Interest on investment, taxes, etc.1/	333	
Total	2,000	
Maintenance and repairs (estimated)		1.00
Fuel (0.37 gallon per hour)		.052
Lubricants (0.13 gallon per hour)		.104
Total		1.156
		($0.0193 per minute)

1/ Ten percent of average annual investment.

Data from which costs were estimated. Estimated life of tractor: 6,000 hours; cost (1949), with winch: $5,000; estimated cost of 3,000-hour overhaul: motor overhaul $500, rollers and track $300, pins and bushings $200, total $1,000; period of operation to date: 374 hours; fuel consumed: 140 gallons at $0.14; oil used (all weights): 50 gallons at $0.80.

Table 14.--Hourly direct cost rates per crew

Crew	Labor	Tools	Tractor	Total per hour
	- - - - - Dollars	- - - - -		
3-man power chain saw crew (one man at 90 cents, two at 75 cents per hour)	2.40	0.58		2.98
3-man crosscut saw crew (all at 75 cents per hour)	2.25	.06		2.31
2-man crosscut saw crew or two-man bow saw crew (all at 75 cents per hour)	1.50	.06		1.56
1-man with double-bitted ax (75 cents per hour)	.75	.02		.77
Skidding crew (one man at $1.25, two at $0.75 per hour)	2.75	.10	1.16	4.01